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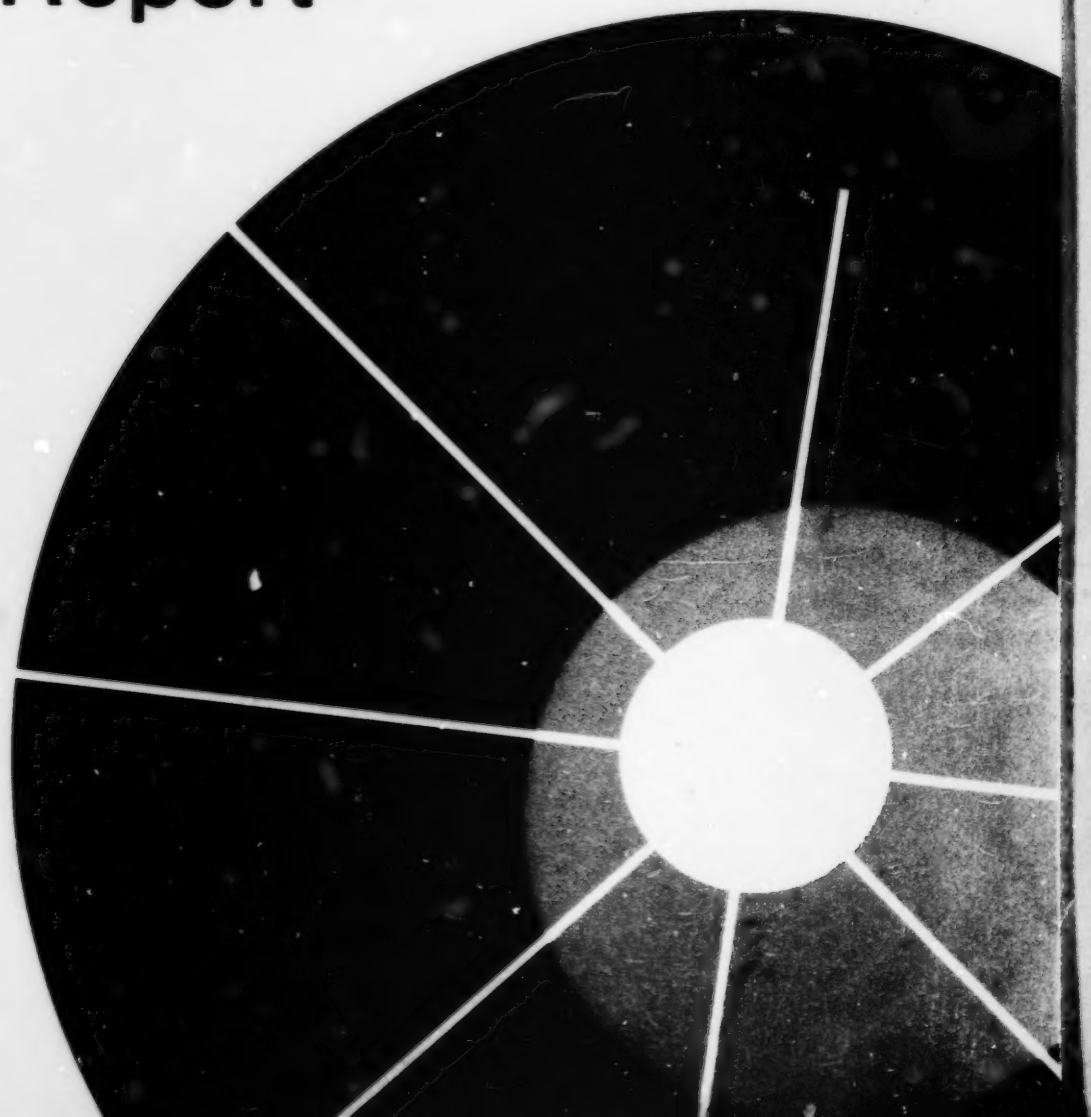
Canada - Saskatchewan Renewables — Conservation Demonstration Program

Final Report



CANADA-SASKATCHEWAN CONSERVATION AND RENEWABLE ENERGY DEMONSTRATION AGREEMENT

On March 18, 1980, the governments of Canada and Saskatchewan entered into a Conservation and Renewable Energy Demonstration Agreement. The Agreement, which terminates March 31, 1984, funds the development and demonstration of a wide range of conservation and renewable energy technologies. The program is funded on an equal cost-shared basis by Canada and Saskatchewan, and is administered by Saskatchewan.

The objectives of CREDA are:

— To develop and demonstrate promising new technologies which exploit renewable energy resources, conserve energy, or make its use more efficient;

— To create employment in new or existing industries;

— To develop broad public awareness of the potential of renewable energy and energy conservation technologies.

This report outlines the results of a project funded by the Government of Saskatchewan as represented by Saskatchewan Energy and Mines, and the Government of Canada as represented by Energy, Mines and Resources Canada, under the terms of the Renewables-Conservation Demonstration Program, and contracted with the party identified herein.

However, neither the Government of Saskatchewan as represented by Saskatchewan Energy and Mines, nor the Government of Canada as represented by Energy, Mines and Resources Canada, accept liability for any errors, omissions, or inaccuracies that may be included in or derived from this report, nor do they assume any liability with respect to the use of, or actions resulting from the use of, any information contained in this report.

Energy Audit: Prince Albert Recreation Centre

Retrofit of Recreation Facilities Project — Phase I

Final Technical Report
on a Renewables-Conservation Demonstration Program Project

Conducted By

Keen Engineering Co. Ltd.

And Supported By

Saskatchewan Energy and Mines
and
Energy Mines and Resources Canada

Project Leader: J.B. Sawers

Miscellaneous
Report FP-9

ACKNOWLEDGEMENTS

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TABLE OF CONTENTS

SUMMARY

1. Introduction
2. Study Method
3. Building Description
   - .1 Development
   - .2 Building Configuration
   - .3 Construction
   - .4 Mechanical System
   - .5 Lighting
   - .6 Occupancy
   - .7 Current Energy Profile
   - .8 Conservation Strategy
4. Energy Conservation Opportunities (ECO's)
   - .1 General
   - .2 No Cost ECO's
   - .3 Low Cost ECO's
   - .4 Medium Cost ECO's
   - .5 High Cost ECO's
   - .6 New and Innovative Retrofit Techniques
5. Conclusions
   - .1 No Cost Retrofit Option
   - .2 Low Cost Retrofit Option
   - .3 Medium Cost Retrofit Option
6. Recommendations

APPENDICIS

A. Terms of Reference
B. Analysis of Energy Bills
C. Building Audit Sheets
D. Computer Simulation of Building
E. Thermographic Report
F. Instrumentation
G. Bibliography
H. Existing Mechanical System Documentation
I. Further Recommendations

SUMMARY

The present building energy index of the Recreation and Senior Citizens Centre, at 36 kWhrs/ft^2/yr, is not excessively high for a facility of this type and age. The Recreation Centre in particular is an efficient cube shape, it has minimal glazing and a limited ventilation system.

The present energy index of the total complex, including pool heating is 53 kWhrs/ft^2/yr.

The implementation of the medium cost retrofit option will result in a net annual saving of $4600.00 at a cost of $9250.00 generating a simple payback period of 2 years.

The savings in both building and total complex energy consumption amount to 17% of the present consumption, resulting in a building index of 30 kWhrs/ft^2/yr and a complex index of 44 kWhrs/ft^2/yr.

1. INTRODUCTION:

On March 11th, 1982 Keen Engineering Co. Ltd. were commissioned by Mr. Dan McFadyen of Saskatchewan Mineral Resources to conduct an energy analysis study of the Prince Albert Recreation and Senior Citizens Centre.

The scope of the study, as defined in the "Guidelines for Tendering", was to identify and report on the potential for energy conservation through;

(a) changes in operating and maintenance procedures.

(b) conventional retrofit techniques.

(c) new and innovative retrofit techniques.

The "Guidelines for Tendering" are included in their entirity in Appendix A, Terms of Reference.

2. STUDY METHOD.

The method used in compiling this report can be broken down into five steps.

2.1 Preliminary Review

The preliminary review consisted of an in office analysis of the building drawings in order to become familiar with the structure and its systems. A second aspect of the preliminary review was an analysis of the building energy bills. This analysis helps determine the relative magnitude of gas and electrical energy consumption. In addition to the above a computer energy analysis of the building was run using a simplified energy analysis program. The analysis provided a further breakdown of the building energy consumption.

2.2 Building Audit

The building audit consisted of a comprehensive on site examination of the building. The results of the audit are contained in the "Building Information for Energy Audit" sheets in Appendix C.

2.3 Pre-Analysis

The pre-analysis consisted of a preliminary "sorting" of energy conservation opportunities (ECO). A master list of energy conservation opportunities was drawn up and compared with the information obtained in the previous two phases. Those items which obviously did not warrant further investigation were eliminated.

2.4 Feasability Analysis

ECO's surviving the phase 3 pre-analysis were considered further in this phase. Those ECO's requiring no capital investment were simply identified and savings estimated where possible. Being "no cost" items a favourable payback period is assured. Those ECO's requiring capital expenditures were analysed where possible to identify savings. Approximate capital costs were then calculated and a payback period derived.

2.5 Report

All of the above phases of the study were drawn together in the report. Much of the detailed information is restricted to the various Appendicis in an effort to keep the body of the report as clear and concise as possible.

3. BUILDING DESCRIPTION.

3.1 Development

The building consists of two separate components. The Recreation Centre which opened in 1966, and the Senior Citizens Centre which was opened in 1978. The complex is centrally located at the corner of 1st Avenue West and 12th Street on property which already contained an outdoor swimming pool. The 1966 Recreation Centre was designed to accomodate the existing pool facility.

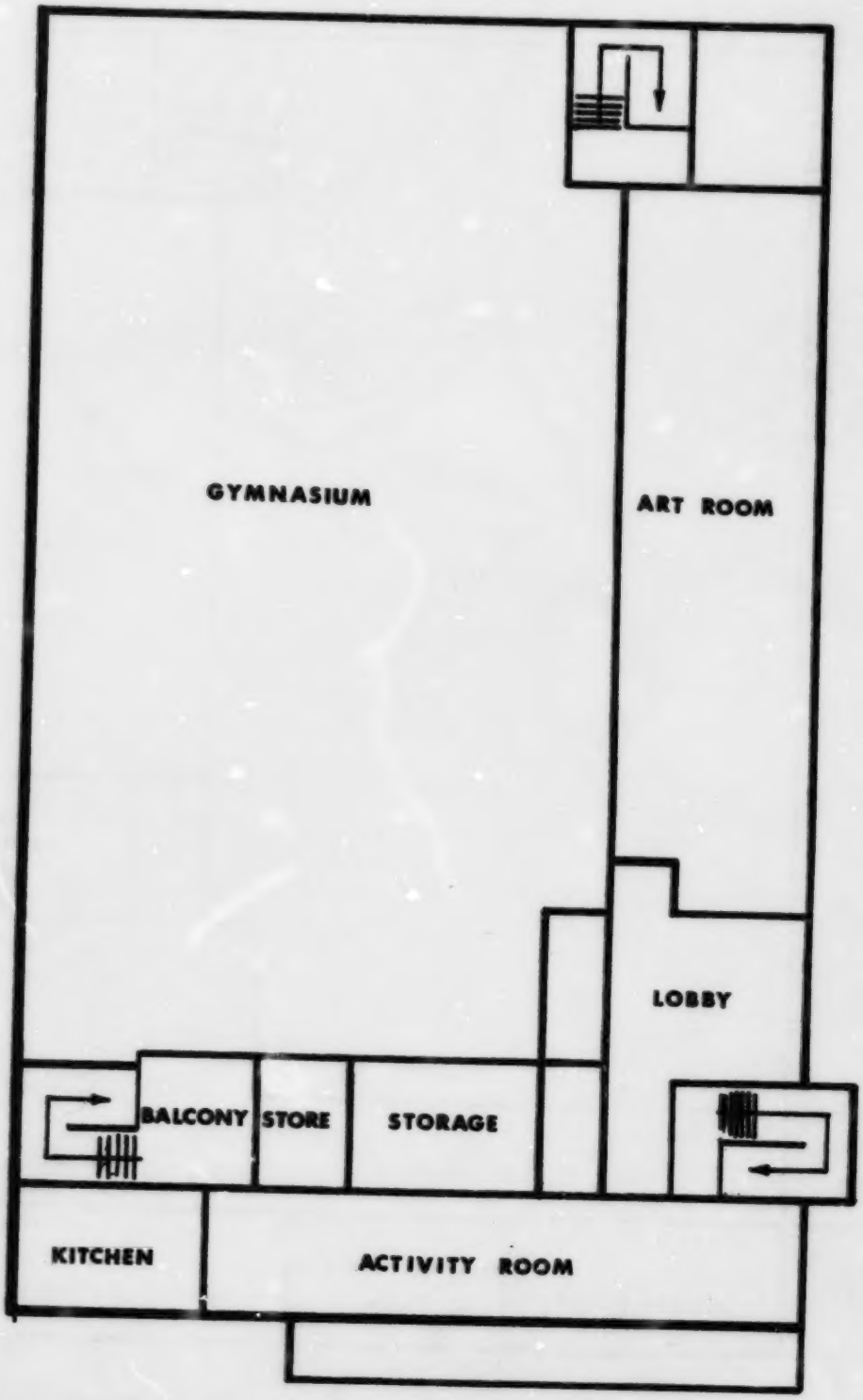
3.2 Building Configuration

(a) Recreation Centre

The Recreation Centre consists of a gymnasium with auxillary service rooms on two above grade and one basement level. The current configuration and use of the various spaces is as indicated on Figure 1 - 3.

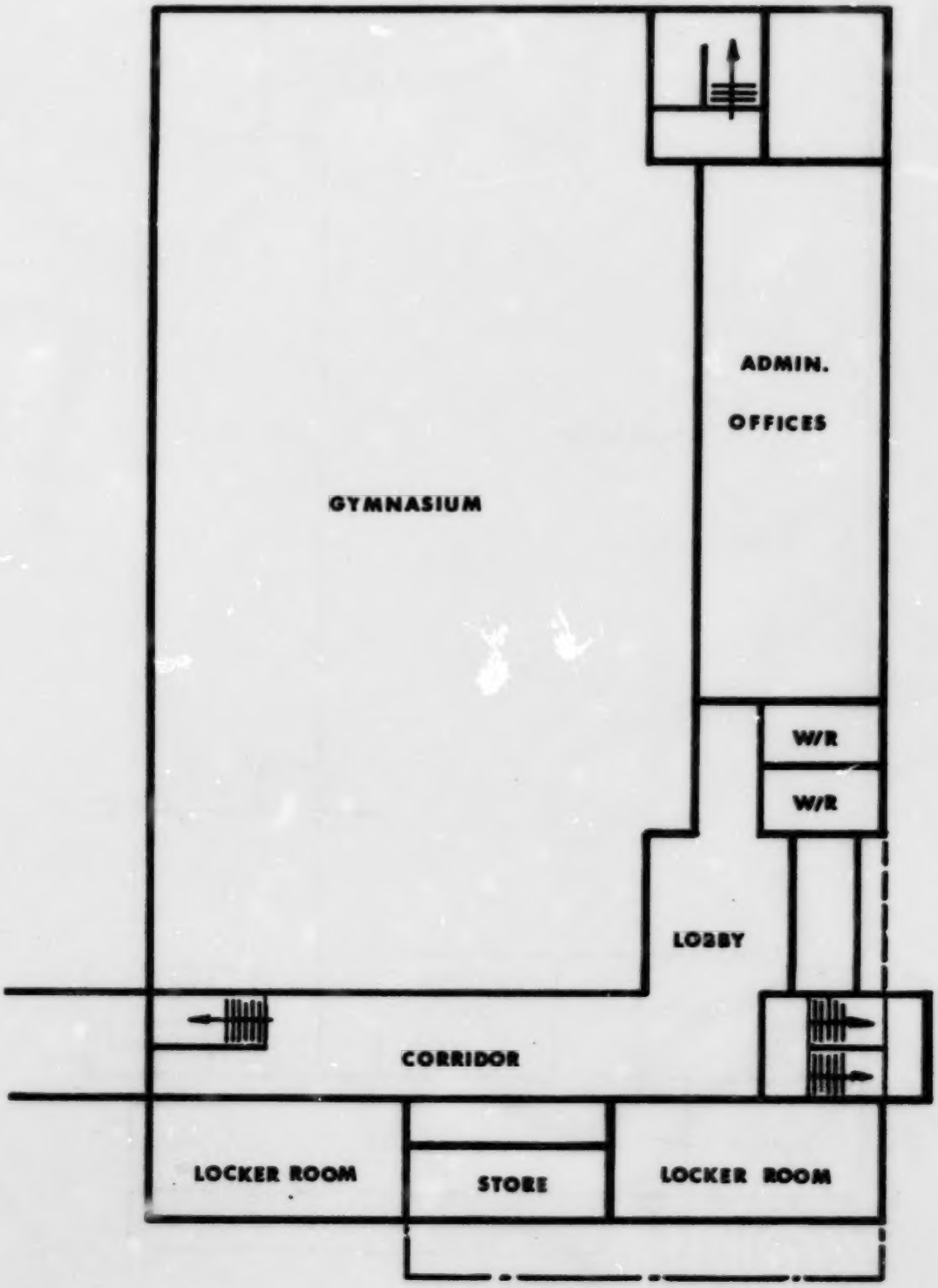
(b) Senior Citizens Centre

The Senior Citizens Centre is a one story building consisting of an activity hall, kitchen, and auxilary service areas. The current configuration and use of the various spaces is as indicated in Figure 4.



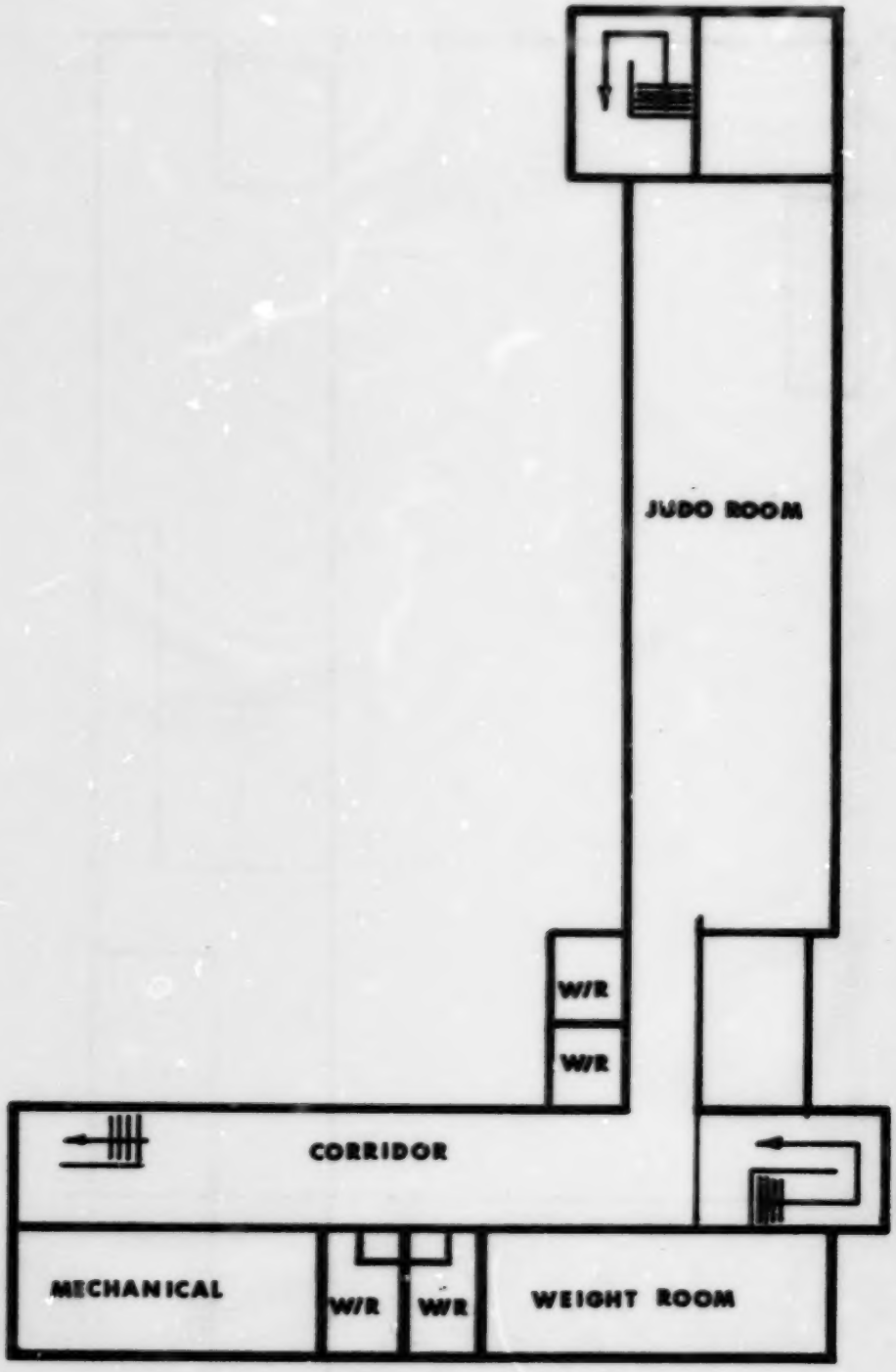
RECREATION CENTRE–SECOND FLOOR

FIGURE 1



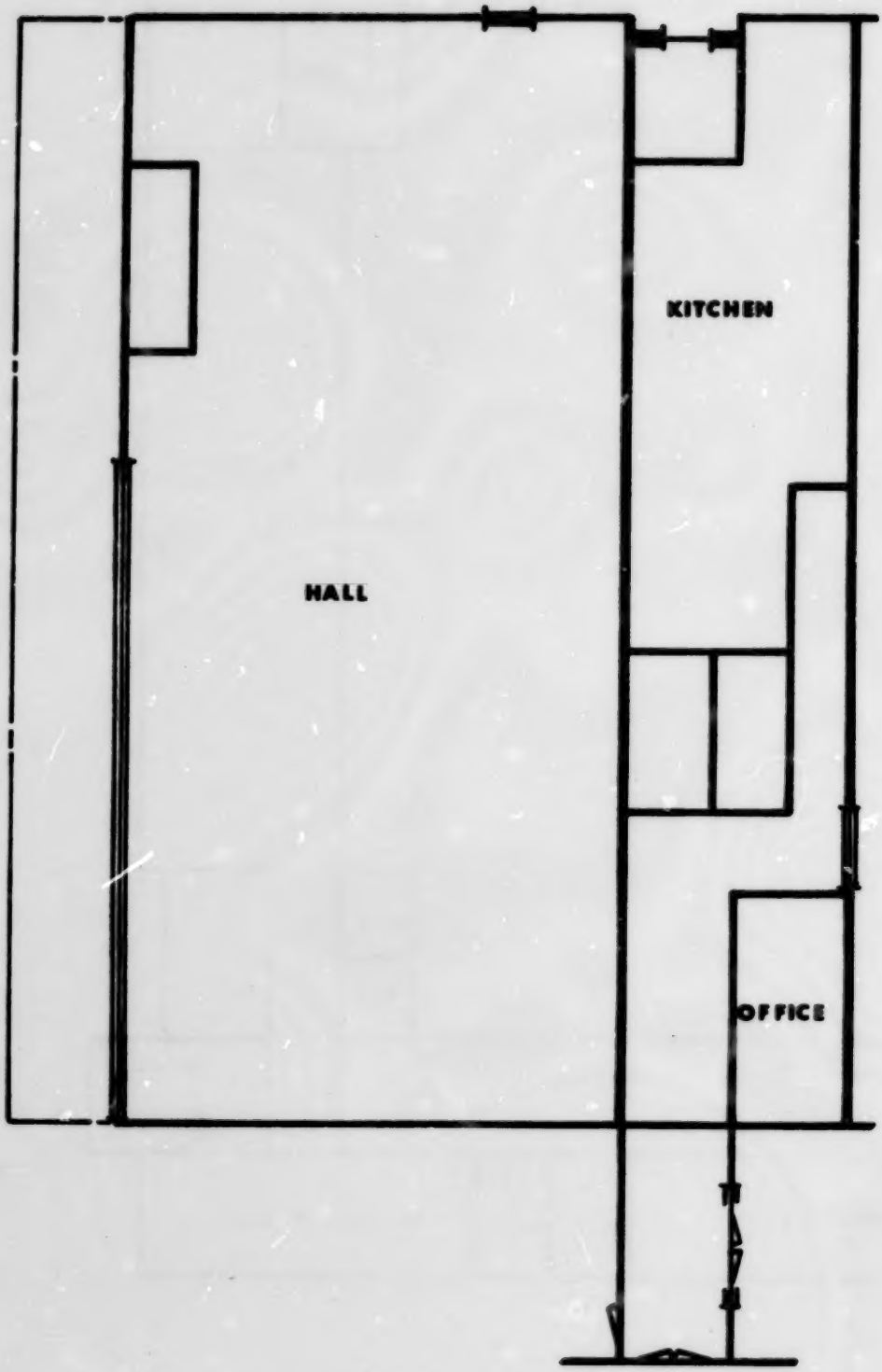
RECREATION CENTRE - MAIN FLOOR

FIGURE 2



RECREATION CENTRE – BASEMENT

FIGURE 3



SENIOR CITIZEN'S CENTRE

FIGURE 4

3.3 Construction

(a) Recreation Centre

The Recreation Centre is primarily of masonary construction. Walls consist of 4" brick, 2" rigid insulation and 6" concrete block (R10). The roof is of metal deck construction with 2" of rigid insulation (R8). All basement walls are of concrete construction, are 10" thick and are insulated, for 4 feet down from grade, with 1½" rigid insulation (R5). Windows are of both the fixed sash and horizontal sliding type. Over the entire building only 6% of the exterior wall is glazed. The south face has 10% glazing with an 8 ft. overhang. All windows have open mesh drapes with liners.

(b) Senior Citizens Centre

The Senior Citizens Centre is primarily of masonary construction. Walls consist of 4" face brick, air space, 1½" rigid insulation and 8" concrete block (R8). The roof is of metal deck construction with 2" of rigid insulation (R8). All foundation walls are insulated with 1½" rigid insulation (R5). Windows are of the fixed sash type. Over the entire building only 10% of the exterior wall is glazed. The south face has 24% glazing with a 4 ft. overhang. South facing windows have bamboo slat blinds.

3.4 Mechanical System

(a) Recreation Centre

The Recreation Centre is heated by means of a multi-zone heating and ventilating unit, and perimeter fin tube heating. The primary source of heat is a 5200 MBH Saskatoon steam boiler. The boiler provides steam to the multi-zone unit heating coil and to steam/water convertors for perimeter heating, domestic water heating, and pool heating. The multi-zone unit has four zones. It heats and ventilates the gymnasium, locker rooms, weight and judo rooms. The zones to the weight and judo rooms appear to have been added sometime after the original installation. Perimeter fin type heating is provided in all areas except the gymnasium.

As mentioned previously the guymasium, locker rooms, judo room and weight room are ventilated by the multi-zone unit. Ventilation is provided to the administration and other activity areas by transfering air from the gymnasium and exhausting or returning air from these spaces. The total supply air quantity of 10,000 cfm is much less than a facility of this size would be provided with under current design practise. The multi-zone unit has no mechanical cooling but does have an economizer cycle and hence free cooling capability.

Air is returned from the various spaces by means of a centrifugal return air fan located in a

3.4 Mechanical System

second floor storage room. Return air is either exhausted or returned to the multi-zone unit. An exhaust air fan located in a second floor storage room exhausts stale air from the washrooms to outside. A range hood and exhaust fan is provided in the second floor kitchen.
The intended controls sequence of operation is as outlined on the sheet titled "Control Operation" taken for the original tender documents and included in Appendix H. Actual operation will be discussed later.

(b) Senior Citizens Centre

The Senior Citizens Centre is heated by means of a rooftop heat/cool single zone unit and perimeter fin tube heating. The rooftop unit is gas fired. The perimeter heating is supplied with hot water from the main heating water convertor in the Recreation Centre. The hall of the Centre is heated by both the rooftop unit and perimeter heating. Ventilation and air conditioning is provided by the rooftop unit. Auxillary areas are heated by perimeter fin tube heating, no air conditioning is provided. The only ventilation provided is by means of kitchen, washroom, and crawelspace exhaust fans.
The hall has two perimeter heating thermostats in addition to the rooftop unit thermostat. All auxillary areas have their own space thermostat.

3.5 Lighting

(a) Recreation Centre

Flourescent lighting is the main source of lighting in the Recreation Centre, the most predominant fixture being a 4 lamp, 2 ft. x 4 ft. recessed unit. The gym has recently been retrofitted with a similar surface mounted fixture in lieu of the original incandescent pot fixtures. All fixtures are switched from wall on-off switches. Multiple circuiting and hence switching provides a high degree of switching flexibility. Tubes currently being used are 40 watt cool white. A minimal amount of outside feature lighting is provided. These units operate by photo cell control. Lighting levels recorded are outlined in the energy audit data sheets. The average lighting load for the building as a whole is 1.54 watts/ft^2.

(b) Senior Citizens Centre

Flourescent lighting is the main source of lighting in the Senior Citizens Centre. The hall is lit by 2 lamp, 1 ft x 4 ft exposed flourescent fixtures, and auxillary pot type incandescent fixtures. The majority of the auxillary areas are lit by recessed 2 lamp, 1 ft x 4 ft fixtures. The hall has extremely flexible wall switching for all fixtures. Auxillary rooms have their own wall switch. As in the Recreation Centre tubes are 40 watt cool white. Lighting levels recorded are outlined in the energy audit data sheets. The hall lighting load is approximately 4 watts/ft^2.

3.6 Occupancy

(a) Recreation Centre

Current use of the Recreation Centre is far less than in previous years. In 1966 when the building was constructed it was the only gymnasium in the city and the major recreational centre. This position has changed with the spread of High School Gyms and other recreational facilities. In the past groups of up to 500 people might not have been uncommon in the gymnasium. Today there are rarely more than 20-30 people using the gymnasium. Gymnasium use is primarily in the evening with occasional use during the day by groups of up to 6 people. Activity rooms are sporadically occupied during the day and evening by groups of up to 12 people.

(b) Senior Citizens Centre

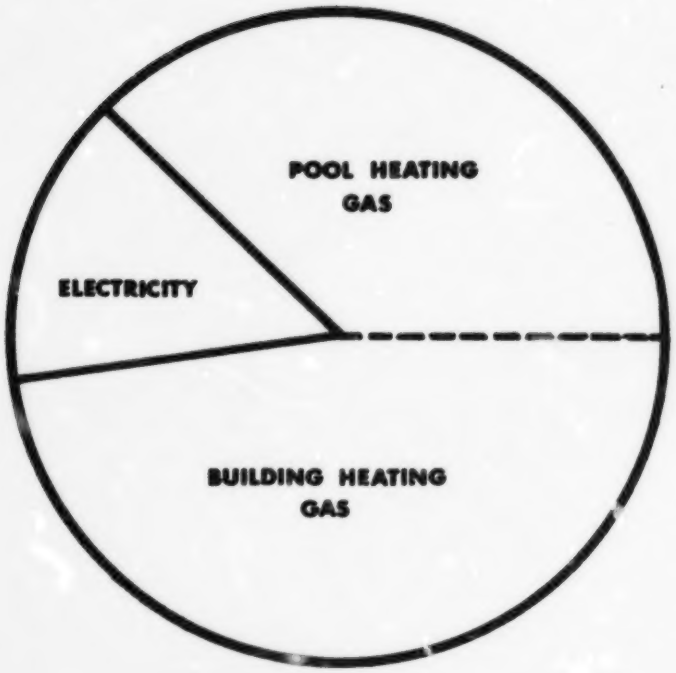
The Senior Citizens Centre is used primarily during the day from 11 am to 4 pm by a group of approximately 24 Senior Citizens. The same group make some evening use of the facility from 4 pm to 11 pm.

3.7 Current Energy Profile

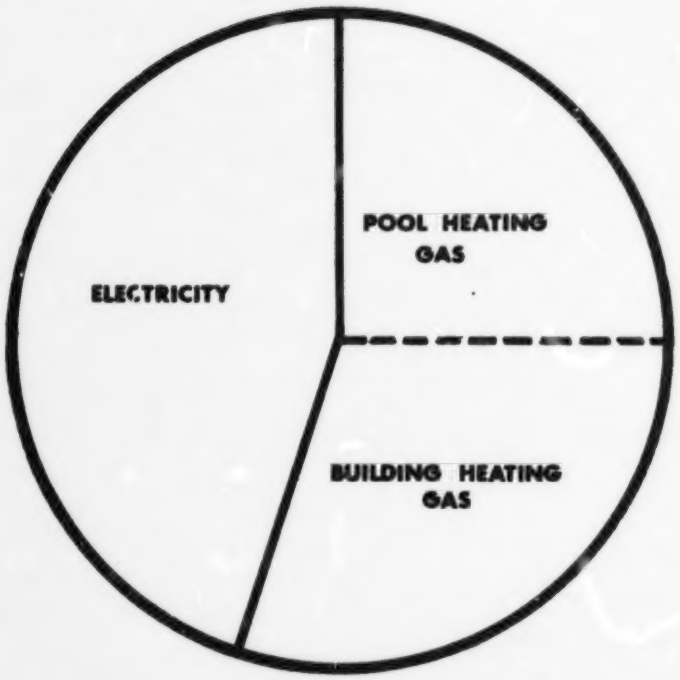
Appendix B indicates a total annual energy index of 53 kW hrs/ft^2/yr. If the pool heating is not considered the "building" energy index is 36 kWhrs/ft^2/yr. Figure 5 shows a breakdown of the energy consumed by the building, including the pool, in terms of both energy consumed and dollars spent.

A simplified computer energy analysis was run on the building (less the pool) in an effort to determine the relative magnitude of the energy sub-systems. Figure 6 is a graphic display of the information obtained. The computer input and output sheets along with a brief explanation of the analysis are contained in Appendix D. Considering the comparative energy index's given in the following section 3.8 "Conservation Strategy", the building energy index of 36 kWhrs/ft^2/yr is not excessively high for a building of this type and age.

The computer analysis of the building indicates that the energy index of the Recreation Centre is 23% less than that of the Senior Citizens Centre. This is as might be expected when one compares the geometry; glazing percentage and mechanical systems of the two areas. The Recreation Centre is geometrically an efficient cube with minimal glazing and a limited ventilating system.



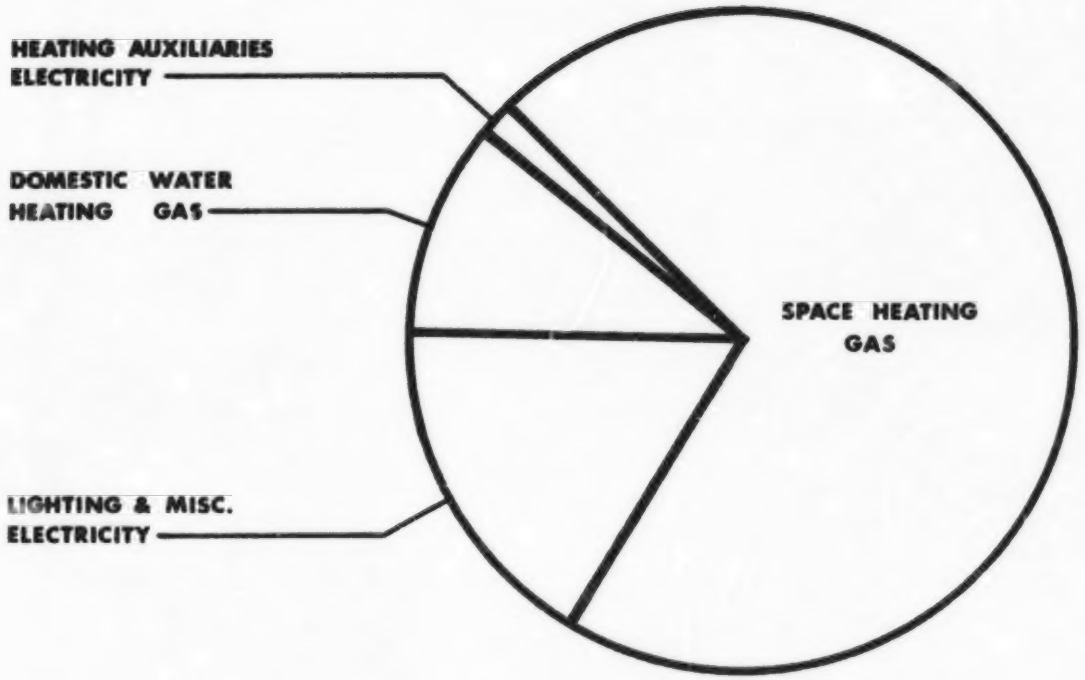
ENERGY

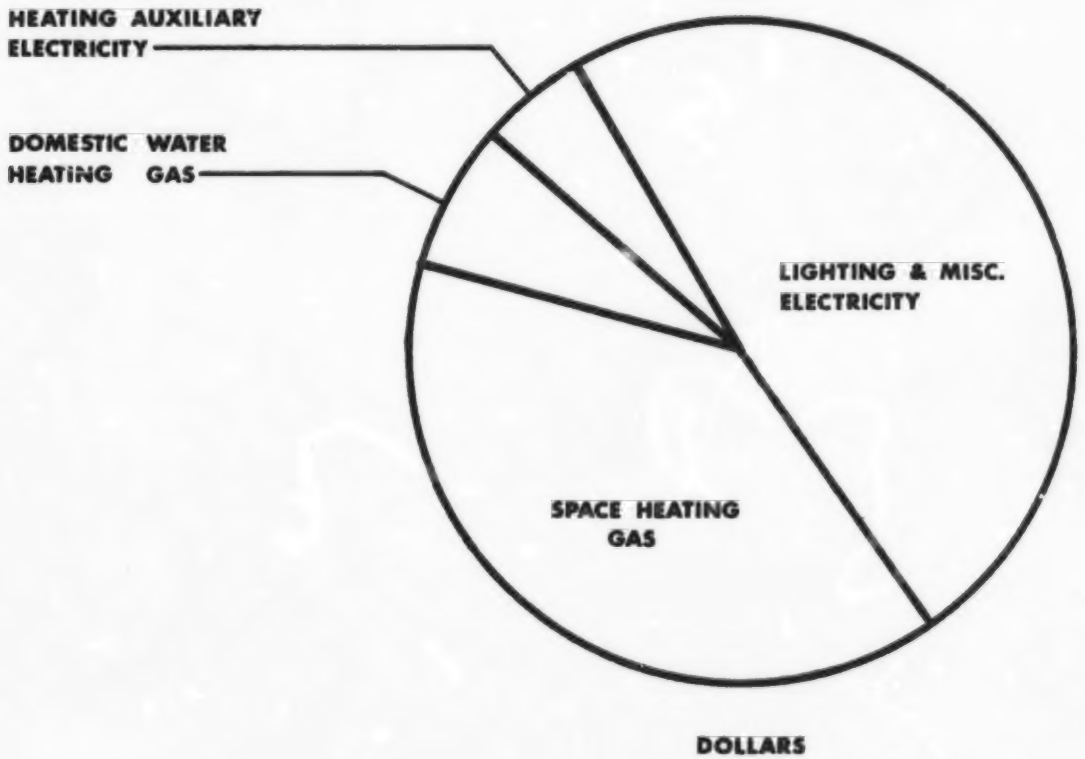


DOLLARS

ANALYSIS OF ACTUAL COMPLEX ENERGY USE

FIGURE 5





COMPUTER GENERATED ANALYSIS OF BUILDING ENERGY USE

FIGURE 6

3.8 Conservation Strategy

In order to arrive at an energy conservation strategy it is necessary to;

(i) have an accurate analysis of the energy being consumed by the building being studied.

(ii) be aware of what is a "reasonable" energy consumption for the building.

Item (i) above was arrived at in the previous section titled "Current Energy Profile". In order to determine what might be considered a "reasonable" energy consumption, for the Recreation and Senior Citizens Centre, the following data was drawn on.

(i) Little information is available on recreation facitity energy consumption. The most similiar building type on which energy consumption information is available are schools. The gymnasium and some evening use are common to both building types.

(ii) In 1979 the Saskatchewan Energy Bus surveyed 13 school buildings. Annual energy index ranged from 29 kWhrs/ft^2/yr to 119 kWhrs/ft^2/yr, with a mean of 51 kWhrs/ft^2/yr. Six of the buildings had an annual index of less than 36 kWhrs/ft^2/yr.

(iii) Current Regina Board of Education guidelines call for new school facilities to have an annual energy index of 26 kWhrs/ft^2/yr.

(iv) A 1975 BOMA study indicated an average annual energy index of 45 kWhrs/ft^2/yr for commercial buildings.

3.8 Conservation Strategy

(v) A 1978 study by Keen Engineering on fifteen commercial properties in Vancouver indicated an average annual energy index of 45 kWhrs/ft^2/yr. Individual values ranged from 25 to 95 kWhrs/ft^2/yr.

(vi) Current Alberta Public Works guide lines call for the annual energy index of new buildings to be less than 26 kWhrs/ft^2/yr.

(vii) Current building designs incorporating strict energy conservation techniques have estimated energy budgets of less than 20 kWhrs/ft^2/yr.

Considering the above points and the fact that the majority of the facility being studied is sixteen years old, our conservation strategy will be to;

- investigate the possibility of reducing the cost of pool heating.
- reduce the building energy index to 25-30 kWhrs/ft^2/yr.

4. ENERGY CONSERVATION OPPORTUNITIES (ECO'S).

4.1 General

Each ECO is discussed in three parts:

(a) the existing condition or procedure.

(b) proposed modification to the existing condition.

(c) the economics of the modification.

It should be noted that manual calculation of ECO savings do not allow the effect of previous ECO's to be considered. Some changes will have an effect of the savings produced by subsequent changes. Each ECO is considered independently and the combined effect estimated.

Savings computed are with respect to the average annual energy consumptions calculated in Appendix B. Dollar values assigned to the energy savings are in terms of April 1982 fuel costs.

Reference to the total complex energy consumption includes pool heating. Building energy consumption is the consumption of the buildings themselves less pool heating.

The ECO's are grouped into five categories:

(a) no cost - maintenance and operating changes.

(b) low cost - minor changes requiring low capital investment.

(c) medium cost - changes requiring moderate capital investment.

(d) high cost - changes requiring significant capital investment.

(e) new and innovative techniques.

4.2 No Cost Energy Conservation Opportunities.

Those ECO's classified as "No Cost" are those that can be carried out immediately by building personnel to reduce wastage of energy. They relate to building operation and maintenance procedures and generally have little or no effect on occupant comfort. For ease of reference all "housekeeping" opportunities will be listed under ECO #1 and subscripted (a), (b), (c), ----- etc.

4.2.1 ECO #1: Changes in Operating and Maintenance Procedures.

a. Regularly perform preventative maintenance of mechanical equipment as outlined in original project documentation. Refer to Appendix H.
b. Replace worn or broken weatherstripping around operable windows. If possible, install weatherstripping where none was installed previously.
c. Weatherstrip operable sash if crack is evident.
d. Consider posting a small sign next to each operable window instructing occupants not to open window while the building is being heated or cooled.
e. Replace any worn or broken weatherstripping. Install weatherstripping where none has been installed previously.
f. Rehang misaligned doors.
g. Caulk around door frames.
h. Inspect all automatic door closers to ensure they are functioning properly. Consider adjustment to enable faster closing.
i. Consider placing a small sign next to each door leading to the exterior or unconditioned spaces advising occupants to keep door closed at all times when not in use.
j. Establish rules for all building personnel regarding opening and closing of doors, directing them to keep them closed whenever possible.
k. Consider installing automatic door closers on all doors leading to the exterior or unconditioned spaces.
l. Consider closing outside air dampers during the first and last hours of occupancy and during peak loads.
m. During the cooling season evening and night hours, flush the building with cooler outdoor air.

4.2.1 ECO #1: Changes in Operating and Maintenance Procedures.

n. When appropriate, consider closing supply registers and radiators and reducing thermostat settings or turning off the electric heaters in lobbies, corridors and vestibules.

o. When the sun is not shining during the heating season, close interior shading devices to reduce radiation from body to cold window surfaces.

p. Wear heavier clothing during the heating season and lighter clothing during the cooling season.

q. Reduce internal heat generation as much as possible during the cooling season. Typical sources of heat generation include lighting, people, machines, cooking equipment, etc.

r. Campaign for better utilization by using letter, memos, signage and personal contact to encourage occupants-especially custodial personnel-to use lighting only when it is needed, to use only the amount of lighting required, and to turn off lights whenever they are not being used.

s. Post a small sign or chart near each switch which identifies which lights are controlled by the switch. This enables the user to be more selective while also reducing trial-and-error which can consume significant amounts of energy as banks of lights are quickly activated and deactivated.

t. Move desks and other work surfaces to a position and orientation that will use installed luminaires to their greatest advantage (instead of moving luminaires).

u. Lamp efficiency deteriorates over the life of a lamp. Light output should be checked regularly with a calibrated light meter by maintenance personnel. When the light output of a group of lamps has fallen to approximately 70% of the original light output, relamp all fixtures in the group at the same time.

4.2.1 ECO #1: Changes in Operating and Maintenance Procedures.

v. Lamps should be wiped clean at regular intervals to assure maximum efficiency.

w. Luminaire efficiency can be maintained by properly cleaning the reflecting surfaces and shielding media. Replace lens shielding that has yellowed or become hazy with a clear acrylic lense with good non yellowing properties.

x. Clean ceilings, walls and floors frequently to improve reflective qualities. When daylight is used, wash windows frequently to maintain illumination levels on tasks which require some natural illumination.

y. Consider fitting existing hot water faucets and showers with flow restrictors.

z. Reduce generating and storage temperature of domestic hot water to the minimum required for washing, usually about 110°F.

4.2.2 ECO #2: SPACE TEMPERATURE RESET

(i) Existing Condition

All space temperatures are set at 70°F year round.

(ii) Proposed Modification

Manually change thermostat settings to 68°F in winter and 78°F in summer. This modification may not be applicable to the Senior Citizens Centre where the occupants are more sensitive to space conditions.

(iii) Economics

This modification was run only for the Recreation Centre as Senior Citizens are generally sensitive to space conditions. Figures D13 indicates a total reduction of 3.5% in energy consumed. As might be expected the majority of the savings obtained are for natural gas which shows a 3% reduction to the average annual building consumption (less pool) would result in an annual saving of approximately $3000m^3$ of natural gas or $336.00.

4.2.3 ECO #3: DELAMPING

(i) Present Condition

Lighting levels in some areas are high enough to warrant selective delamping. Specific areas are the Senior Citizens Centre hall, and activity room and some corridor spaces in the Recreation Centre.

(ii) Proposed Modification

Remove as many tubes as is practical in the areas mentioned above while maintaining adequate lighting levels.

(iii) Economics

The Senior Citizens hall alone has a lighting load of approximately 14 kW. If say 5 kW of this could be removed, and the recorded lighting level would suggest that it could, then assuming 56 hours of operation per week the annual saving would be 14,560 kWhrs or at April 1982 rates $640.00.

As was found in ECO #6 the reduction in lighting load will result in an additional gas heating load. By proportion from ECO #6 an increase in gas consumption of 1500 m^3 might be expected with a net saving of $475.00.

4.3 LOW COST ENERGY CONSERVATION OPPORTUNITIES

Low cost ECO's are those requiring a capital investment of less than $1000.00. All low cost ECO's require changes to systems or building elements. Payback periods determined are the simple payback period, ie; capital cost/annual saving.

4.3.1 ECO #4: RECREATION CENTRE NIGHT SETBACK.

(i) Existing Condition:

Presently the Recreation Centre has no night setback control. A day/night switch was provided in the original design. The original sequence of operation (refer to Appendix H) called for the outside air damper to close and the fan and heating to cycle on and off to maintain a night setting of 60°F. The day/night switch is not being used.
A test of the day/night switch indicated that the outside air damper did close but that the fan continued to run.

(ii) Proposed Modification:

Modify existing night setback control to provide cycling of fan and heating coil to maintain a temperature of 55°F. Provide new night setback controls to reset heating water temperature at night. Provide time clock for automatic use of this system between 11:00 pm and 7:00 am.

(iii) Economics:

This modification was run in conjunction with ECO #2, space temperature reset. Savings are therefore computed using Figure D13 as the base. Figure D14 indicates a total reduction of 16% in energy consumed. As for ECO #1, the majority of the savings obtained are for natural gas which shows a 15% reduction in building gas consumption. Relating this reduction to the average annual building consumption (less pool) would result in an annual saving of 15000 m^3 of natural gas or $1600.00. The

4.3.1 ECO #4: RECREATION CENTRE NIGHT SETBACK.

(iii) Economics:

estimated cost of the proposed modifications is $500.00.

The simple payback period for this modification is therefore 4 months.

4.3.2 ECO #5: SENIOR CITIZENS CENTRE NIGHT SETBACK.

(i) Existing Condition

The Senior Citizens Centre has three thermostats in the main hall and numerous other heating only thermostats in auxiliary spaces. Two of the hall thermostats control the perimeter fin tube heating. The third controls the rooftop heat cool unit.

(ii) Proposed Modification

ECO #3 by resetting the heating water temperature at night will provide night setback in the Senior Citizens Centre. In order to allow the perimeter heating to fullfil this function the rooftop unit heating setpoint should be set down to just below the desired night setback temperature. Alternatively the rooftop unit could be locked out at night by time clock control.

(iii) Economics

A computer analysis of this modification was not carried out as it seemed reasonable to extrapolate the results of ECO #3. From the results of ECO #3, an annual saving of approximately 3000 m^3 of natural gas or $336.00 might be expected for the Senior Citizens Centre. The cost of providing a time clock would be of the order of $150.00. The simple payback period is therefore 6 months.

4.3.3 ECO #6: LIGHTING LOAD REDUCTION.

(i) Existing Condition

Lighting levels vary throughtout the facility. It was felt that the levels were generally high enough to warrant the use of a lower wattage fixture.

(ii) Proposed Modification

As tubes are replaced, use 35 watt tubes in lieu of the 40 watt tubes currently being used.

(iii) Economics

This modification was run subsequent to ECO's #2&3 on the energy analysis program for the Recreation Centre. Savings are therefore computed using Figure D14 as the base. Figure D15 shows no reduction in overall energy consumption. As can be seen from the program output, the lighting load decreases but is offset by an increase in the heating load. Electricity consumption decreases by 6% and gas consumption increases by 2%. In terms of the average annual building energy consumption the above is equivalent to a decrease of 16,747 kW hrs and an increase of 1700 m^3 of natural gas resulting in a net annual saving of $546.00.

4.3.4 ECO #7: EXHAUST FAN INTERLOCK.

(i) Present Condition

In accordance with the original controls sequence of operation (refer to Appendix H) the washroom exhaust fan in the Recreation Centre runs continuously.

(ii) Proposed Modification

Interlock the exhaust fan with the new time clock provided under ECO #3 to ensure that it only runs during occupied periods.

(iii) Economics

The cost of this modification is minimal. It will provide a small annual saving of approximately 500 kW hrs. but will prevent a much larger heat load which would result from negative pressurization if the exhaust fan were to continue running when the supply air system was not.
As a result of the minimal capital cost a favorable payback period is assured.

4.3.5 ECO #8: BOILER CONTROL IMPROVEMENT

(i) Existing Condition

Boiler flue gas analysis indicated the following.

	Flue Gas Temp Rise (°F)	$\%O_2$	$\%CO_2$	% Excess Air	% Effic.
High Fire	300	6	8	45	81.0
Low Fire	250	10	6	100	83.5

Observations indicated that the vast majority of boiler operation is on low fire.

(ii) Proposed Modification

Have qualified boiler technician reset combination controls to reduce excess air on low fire.

(iii) Economics

An increase of 1.5% to 85% efficiency can be expected from this modification. In terms of the total building gas consumption, a 1.5% reduction is equivalent to an annual saving of 1300 m^3 of natural gas or $145.00. The cost of this modification would be approximately $400.00, resulting in a simple payback period of 3 years.

4.4 Medium Cost Energy Conservation Opportunities.

Medium cost ECO's are those requiring a capital investment of between $1000.00 and $10,000.00. Where the simple payback period is greater than 5 years the true payback period is derived using a 9% interest rate and 12% fuel escalation rate.

4.4.1 ECO #9: RECREATION CENTRE HOT & COLD DECK RESET.

(i) Present Condition

The Recreation Centre multi-zone air handling unit presently operates as described in the original sequence of operation (refer to appendix). The important aspects are that during the heating season;

- the mixed air is controlled at a fixed 50°F (measured value of 55°F).
- the hot deck is controlled at a constant 80-84°F.

As recorded on the audit sheets the lowest temperature required by any zone was 60-62°F, and the highest 65-66°F.

(ii) Proposed Modification

Current multi-zone system designs utilize hot and cold deck reset control. The cold deck, or in this case the mixed air temperature, is controlled by the zone with the highest "cooling" requirement and the hot deck temperature is controlled by the zone with the largest heating requirement. The two extreme zones therefore utilize 100% "cold" (mixed) deck air and 100% hot deck air respectively. Other zones lying between these two extremes mix not and cold deck air as required. This system minimizes reheating of supply air.

4.4.1 ECO # 9: RECREATION CENTRE HOT & COLD DECK RESET.

(iii) Economics

The temperature of the cold or mixed deck of the multizone system is provided by free cooling. The primary saving will therefore be in not over heating the hot deck air.

Hot Deck Savings = [Hot Deck Flow (cfm) x 1.08]
x [hot deck summer reset (°F)
x length of summer (weeks/yr)
+ hot deck winter reset (°F)
x heating season length (weeks/yr)]
x operating hours/week.
= [5000 x 1.08] x [1 x 15.5 + 5 x 36.5] x 95
= 102,000 MBTU/yr
= 1000 therms
= 3000 m^3

Related to the average annual building gas consumption (less pool) a reduction of 3000 m^3 represents an annual saving of $336.00.

The estimated cost of this modification is $1200.00.

The simple payback period is therefore 4 years.

4.4.2 ECO #10: OUTSIDE AIR DAMPER LEAKAGE.

(i) Present Condition.

With the multizone unit day/night switch in the night position the outside, return and mixed air temperatures were measured. The recorded values are noted in the Recreation Centre audit data sheets in Appendix C. By proportion the measured temperatures indicated a damper leakage rate of 6%.

(ii) Proposed Modification

Replace existing outside air damper with new low leakage (2%) damper.

(iii) Economics

Damper Leakage Saving = Leakage Reduction (cfm) x 1.08 x average heating season temperature rise (°F).

= (0.04 x 10000) x 1.08 x 50 x 73

= 56,765 ft^3

= 1600 m^3 natural gas.

This reduction in gas consumption would result in an annual cost saving of $179.00. The cost of implementing this modification is approximately $1000.00. The simple payback period is therefore 6 years. It should be noted that if ECO #3 is implemented in its entirity and the multi-zone fan is cycled on a demand for heating, the savings from this modification would be significantly reduced.

4.4.3 ECO #11: POOL THERMAL BLANKET

(i) Existing Condition

No cover on pool at night results in substantial night heat loss.

(ii) Proposed Modification

Install removable thermal blanket to conserve pool heat overnight.

(iii) Economics

Thermal blanket manufacturers claim energy savings in pool heating of between 20% and 50%. For the purpose of this analysis the lower figure of 20% will be used.
The summer gas consumption from Appendix B is 68110 m^3. Based on the number of showers, pool heating must account for at least 60,000 m^3 of the summer gas load a saving of 20% therefore represents 12,000 ft^3 of natural gas, or at April 1982 fuel costs, $1345.00. The estimated cost of installing the pool cover is $7000.00. The simple payback period is therefore 5.2 years. Considering a 9% interest rate and 12% fuel cost escalation rate the true payback period becomes 5 years.

4.5 High Cost Energy Conservation Opportunities

High Cost ECO's are those requiring a capital investment of more than $10,000.00. All high cost ECO's require substantial changes to systems or building elements. Payback periods computed are true payback periods considering a 9% interest rate and 12% fuel escalation.

4.5.1 ECO #12: BUILDING INSULATION.

(i) Present Condition

Present insulation levels for both the walls and roof of the Recreation Centre are R10.

(ii) Proposed Modification

For the purposes of estimating possible savings an additional R10 was considered to be added to both the walls and roof giving a total of R20.

(iii) Economics

This modification was run on the Recreation Centre in conjunction with ECO's 2,3,& 5. Savings are therefore, computed using Figure D15 as the base. Figure D16 indicates a total reduction of 22% in energy consumed. The most significant aspect is the reduction in gas consumption. This reduction related to actual building consumption represents an annual saving of approximately 14000 m^3 of natural gas or $1570.00. The net internal wall and roof area of the Recreation Centre is approximately 28,000 ft^2. At an average installed cost of $2.25 per ft^2 the total installation cost would be of the order of $63,000.00. Assuming an average fuel excalation rate of 12% and average interest rate of 9% the true payback period would be 27 years.

4.6 New and Innovative Retrofit Techniques.

New and Innovative technology, with respect to building systems, generally include waste heat reclamation systems, solar energy systems, energy storage systems and building automation systems. The applicability of any one of these technologies depend on numerous factors. All of them, however, require substantial capital expense.

4.6.1 General

Waste heat reclamation systems require a "source" of waste heat. In buildings this source of waste heat is commonly air being exhausted from the building. It is generally agreed that systems with controlled exhaust air quantities of 4000 cfm or more warrant an analysis of the economics of a waste heat recovery system. The Recreation Centre has a total controlled exhaust air quantity (measured) of 1330 cfm. This air quantity is 33% of the 4000 cfm mentioned above. The two exhaust air systems are remote from each other and the fresh air intake duct. Waste heat recovery was thus discounted as a viable possibility.

Solar energy systems for economic reasons are still far from common. Numerous studies by ourselves and other published data conclude that, even at todays energy costs, space heating systems are simply not viable. Domestic hot water or pool heating systems however offer much more promise. Pools in particular require lower water temperatures and for the Recreation Centre the heating requirement is for the summer months only when the available solar energy is more abundant. Both of these factors combine to increase a systems efficiency and hence improve the economic benefits. The possibility of using solar energy to heat the Recreation Centre swimming pool is analysed later in this section.

4.6.1 General

Energy storage systems generally relate to the storage of reclaimed heat from a building cooling system, the storage of "cool" from off peak running of refrigeration machines or the storage of solar energy. Only the latter option has possible application to the Recreation and Senior Citizens Centre and will be considered in the analysis of the pool solar heating system.

Building automation systems can provide constant surveilance of all building systems to enable the most efficient and effective use of energy possible. Building automation systems are most applicable for larger, more complex buildings or groups of buildings. The Recreation and Senior Citizens Centre is by the above definition a small and fairly simple building. A building automation system would thus be inappropriate.

Payback periods computed for innovative retrofit modifications are true payback periods considering a 9% interest rate and 12% fuel escalation rate.

4.6.2 ECO # 13 : SOLAR POOL HEATING.

(i) Present Condition

The main steam boiler is run in the summer months to provide pool heating. Approximately 45% of the natural gas bill is for pool heating.

(ii) Proposed Modification

Provide an active solar collection system to provide pool heating.

(iii) Economics

For the purposes of this analysis an array of 2500 ft^2 was assumed as a starting point. Over the summer months a glazed solar panel utilized for pool heating might be expected to run at an efficiency of 70%. The average daily isolation for the months May-August is 2330 BTUH/ft^2 and hence total daily collected energy would be 2500 x 2330 x 0.7 = 4000 MBTU. For a pool of 90' x 75' ie: 6750 ft^2 the average heat loss over the summer months is approximately 1000 MBTU/hr or 24,000 MBTU/day. An array of 2500 ft would therefore produce approximately 17% of the pool heating. This equates to an annual saving of 10200 m^3 of natural gas or $1143.00. An array of the size in question could be installed at a cost in the order of $100,000.00. Considering an annual interest rate of 9% and 12% fuel escalation the true payback period is approximately 50 years.

5. CONCLUSIONS.

An attempt was made to present five retrofit options as requested in the "Guidelines for Tendering". However, reviewing ECO's #1 - #13 (refer to table 5.1 over) and the payback period determined for each modification, it would be reasonable to conclude that ECO's #12 & #13 are impractical to implement and uneconomic even when one considers significant fuel cost escalation. The project thus offers no high cost or new technology retrofit possibilities.

Three retrofit options, ie; no, low, and medium cost will therefore be presented. It should be noted that manual calculation of ECO savings do not take the cascade effect into account. That is, the savings offered by an ECO will be influenced by the previously implemented measures. The effect this will have on total savings is estimated only for the recommended retrofit option.

ECO #	Capital Cost ($)	Description	Savings			Payback Period (yrs)	
			m^3	kWhrs	Dollars	Simple	True
1	0	Housekeeping	-	-	-	x	-
2	0	Delamping	3000	2000	424	x	-
3	0	Space Temp Reset	(1500)	14560	475	x	-
4	500	Night Setback (Rec)	15000	-	1600	0.33	-
5	150	Night Setback (Sen)	3000	-	336	0.50	-
6	Minimal	Lighting load Reduction	(1700)	16747	546	x	-
7	Minimal	Exhaust Fan Interlock	-	500	22	x	-
8	400	Boiler Control Improvement	1300	-	145	3	-
9	1200	Hot & Cold Deck Reset	3000	-	145	4	-
10	1000	Outside Air Damper Leakage	1600	-	179	-	-
11	7000	Pool Thermal Blanket	12,000	-	1345	-	5
12	63,000	Building Insulation	14,000	-	1570	-	27
13	100,000	Solar Pool Heating	10,200	-	1143	-	50

Table 5.1 ECO's Summary

5.1 NO COST RETROFIT OPTION

From Table 5.1 the no cost ECO's can be identified as #'s 1,2,& 3. The table indicates total savings of 1500 m^3 of natural gas, 16,560 kWhrs of electricity, and hence $899.00 for ECO # 2 & 3.
There will obviously also be some savings from ECO #1, the housekeeping measures.
It seems reasonable to predict a total saving of $1000. per year for this option for no capital investment.
This retrofit option reduces annual energy consumption by a total of 32,000 kWhrs. The new building energy index would be 35 kWhrs/ft^2/yr or a reduction of 3%.
As this option does not address pool heating costs the new complex energy index would be 55 kWhrs/ft^2/yr or a reduction of 2%.

5.2 LOW COST RETROFIT OPTION

In addition to the no cost ECO's the low cost retrofit option includes ECO's 4,5,6,7, & 8.
Thus, from Table 5.1, for ECO's 1 - 8 inclusive, total savings indicated are 19,100 m^3 of natural gas and 33807 kWhrs of electricity resulting in a net saving of $3548.00.
The total capital cost of the low cost ECO's is $1050. giving a total retrofit option simple payback period of 4 months.
This retrofit option reduces annual energy consumption by a total of 230,000 kWhrs. The new building energy index would be 30 kWhrs/ft^2/yr or a reduction of 17%.
Again this option does not address pool heating costs. The new complex energy index would be 49 kWhrs/ft^2/yr a reduction of 11%.

5.3 MEDIUM COST RETROFIT OPTION.

In addition to the low cost ECO's the medium cost retrofit option includes ECO's #9, 10, & 11. As ECO #4 is included the savings from ECO #10 will be reduced significantly. Thus, from Table 5.1, for ECO's #1 - 9 inclusive and #11 total savings indicated are 34100 m^3 of natural gas and 33807 kWhrs of electricity resulting in a net saving of $5229.00.

The total capital cost of the medium cost ECO's is $9250. giving a total retrofit option simple payback period of approximately 2 years.

This retrofit option reduces annual building energy consumption by 261,000 kWhrs. The new building energy index would therefore be 29 kWhrs/ft^2/yr or a reduction of almost 20%.

The reduction in pool heating costs is 124,000 kWhrs. The new complex energy index would therefore be 43/kWhrs/ ft^2/yr or a reduction of 23%.

6. RECOMMENDATIONS.

It is our recommendation that the medium cost retrofit option be implemented.

Considering the cascade effect refered to earlier, realistic expections of this option might be an annual savings of;

(a) 220,000 kWhrs in building consumption thereby reducing the building energy index to 30 kWhrs/ft^2/yr, a saving of 17%.

(b) 120,000 kWhrs in pool heating thereby reducing the complex energy index to 44 kWhrs/ft^2/yr., a saving of 17%.

The above projection would result in a saving of approximately $4600.00 at April 1982 utility rates. The cost of this option is estimated to be $9250.00. The simple payback period is therefore 2 years.